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ABSTRACT

The purpose of this investigation was to assess the general background knowledge of the college non-science major with respect to energy-environmental facts and concepts. It was hypothesized that in general, college students have a rather poor background in and lack an understanding of the current energy crises and the related environmental impacts of energy use. Since the hypothesis was later found to be true (accepted), the second purpose of this study was to develop a two-week six-lecture presentation on "Energy and the Environment" as part of a course in physical science for non-science majors. A pretest and posttest design was used and the treatment group showed significant gain scores (0.01 level). (RH)

The Development and Use of An Energy Environment Assessment Instrument

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INTRODUCTION

The decade of the 1970's has become a time of environmental awareness and the serious impending problem of our energy crises, first the fuel crisis of 1973 and more recently the winter fuel crisis of 1976-77. It becomes imperative that science educators take a strong initiative towards educating their students by incorporating real world relevancy into the science curriculum especially in the areas of our energy problems.

The mass media has in part made the public more aware of the energy crisis and some of the other related environmental problems. However, there seems to exist among the public (college students included) a state of confusion, misinformation, misinterpretation, and overall lack of facts concerning the energy crises.

A brief survey of the literature has shown that some science education research has been done in various areas of environmental education, including new curricular programs, construction of attitude surveys, and value preference instruments. Very little research has been centered specifically upon the energy problem and the environmental impact of energy use.

The United States Energy Research and Development Administration (ERDA) has since 1974 been sponsoring a Citizens' Workshop Program on Energy and The Environment.[2] Several science educators have been supported by ERDA to give workshop presentations to various civic and social as well as professional groups in local communities. This workshop activity provides information to American citizens so that they may be better able to make wise choices as to energy use as related to resultant environmental effects, growth, and the overall quality of life.

The authors of this study believe that there exists a strong need to provide college students with a better understanding of energy-environmental problems. This has been the basic motivation behind this investigation.

PURPOSE

The main objectives of this investigation were to develop a test instrument to assess the general background knowledge of college non-science majors with respect to energy-environmental facts and concepts and to use the instrument to assess the knowledge gained as result of the development of a six-lecture-discussion-presentation unit on "Energy and the Environment".

It was hypothesized that in general, college students have a rather poor background in and a lack of understanding of the current energy crises and the related environmental impacts of energy use. It was also hypothesized that non-science majors would make significant gains in scores on the assessment instrument as a result of the instruction on energy and the environment.

PROCEDURE

A twenty-item multiple choice test instrument was constructed. The test items were written and developed and were based upon the general content material used in the Citizens' Workshop program.[1,2] The instrument was titled Energy-Environment Quotient (E^2Q) (See Appendix A).

The content validity of the instrument was established, based upon the expert judgement of three college science educators. One of the authors involved in the validity judgement is currently an active participant in ERDA's Citizens' Workshop programs. The internal reliability was determined using the Kuder-Richardson Formula and it was found to be 0.72.[3]

The student samples used in the study were from different sections of classes of non-science majors from two universities in Western Pennsylvania. A few high school groups in the area were also given the E^2Q instrument.

The treatment groups consisted of 24 student volunteers who were first pre-tested with the E^2Q instrument and then after given the treatment (6 lectures with presentations). The students were then post-tested with the same test instrument.

The content material used in the presentation unit "Energy and the Environment" was developed and included the following in topical outline:

I. Some Causes of the Energy Crises

II. Energy Concepts

- A. The Laws of Thermodynamics
- B. Energy Quality
- C. Energy Efficiency
- D. Net Energy

III. Current Energy Flow in the U.S.

IV. Energy Alternatives

V. Environmental Impacts of Energy Use

VI. Use of Energy-Environment Simulator

The activities included lecture presentations, discussions, use of slides, audio-tapes, overhead transparencies and other useful aids from the ERDA Technical Information Center.[2] The high-light of the presentation included the demonstration and use of an Energy-Environment Simulator (See Appendix B). The simulator is an analog computer decision-making game. A total of 31 variables are programmed into the instrument including the energy resources and our energy demands along with the related environmental impacts and the overall quality of life effects. The students have the opportunity to interact

with the instrument. They are able to make judgements and decisions concerning the various variables. The ESS is a time machine, where the time ticks away at a 100 years per minute and the students try to get their fossil fuels to last as long as possible.

During the height of the 1976-77 winter fuel energy crises in Western Pennsylvania, we decided to administer a survey on the first day of the winter term. The survey question was "Do you really think there is an energy crisis?" Yes No Not Sure "Briefly explain reason(s) for your answer above." We were interested to see if students were aware of the seriousness of the situation since at the time they were being made aware of the situation as a result of the mass media.

FINDINGS

The results of administering the E^2Q to the various groups are summarized in Table 1. The overall mean scores of all the groups are very low ranging from 6.25 to 7.81 (These scores are not very much different from pure guessing).

The treatment group used the pre-test, post-test design and the results are summarized in Table 2. A correlated t-test was used and the results were significant at well beyond the 0.001 level. The treatment presentation apparently was very effective in terms of the gain scores on the E^2Q instrument.

The open-ended survey given to another group at the beginning of the winter semester 1977 is summarized below:

"Do you really think there is an Energy Crises?"	Yes	No	Not Sure
	72	23	43

The explanations for their answers were many and varied. Of those who said yes, their many explanations centered around the natural gas shortages in Pennsylvania. About 10, stated that they did not have any definitive reasons

except for saying that they were influenced by what they read in the media. About 20 students blamed wasteful energy-use habits by the American consumers and stressed more conservation. About half of the 72 who stated Yes, had some good conception of the energy crises. They stated references to our reliance on non-renewable fossil fuels, lack conservation efforts, and overall population increases as well as increases in per-capita energy use.

Analyses of those 23 who stated No indicated a general skepticism on the part of big business and industry and the government as well. Most of them concluded that the crises was contrived.

Those 43 students who stated Not Sure explained a lack of background knowledge in the overall energy picture. Some students were also skeptical about the energy crisis being contrived.

Table 1 Summary of Students Surveyed with E^2Q Instrument

Physical Science Students (Non-science majors)	Elementary Education majors	High School Groups	
		A	B
n = 139	n = 51	n=57	n=14
$\bar{X}$ = 7.81	$\bar{X}$ = 6.92	$\bar{X}$= 6.25	$\bar{X}$= 7.36
s.d.= 2.15	s.d.=2.01	s.d.=1.96	s.d.=2.27

Table 2 Pre-test - Post-Test Design for Treatment Group

Physical Science Students Non-Science Majors	
Pre-Test	Post-Test
n = 24	n = 24
X = 7.13	X = 13.46
s.d. = 2.15	s.d. = 3.21
*t = 9.81	
Probability >> 0.001	

*Correlated t-test

The general overall impression from reading the open-ended explanations was that the students related the energy crises to many inter-disciplinary areas. Such areas as industry, technology, population, human behavior (wasteful habits), government and policits, were mentioned in many of the explanations.

DISCUSSION OF FINDINGS

An extensive item-analysis of the E^2Q instrument showed a need for some item revision and deletion. Some items were too specific with respect to content material and needed to be changed to a more generalized information. Attempts are currently being made to increase the number of items to 24 or 30. The E^2Q can be administered in about 10 minutes of time and did provide a general assessment of an individual background knowledge on Energy and the Environment.

The E^2Q did prove useful with respect to its use in the treatment group. It did in a way validate the treatment presentation. However post-hoc item-analysis of the post-test scores did reveal some rather weak items.

The open-ended written protocols of the 1977 survey served to strengthen our belief in the need to include energy-environment topics in those science courses for non-science majors. In fact the data strongly hints to a new course using an interdisciplinary approach. G. T. Miller, an ecologist proposes a model (See Appendix C) which describes the many factors that could be involved in such an interdisciplinary course.

SUGGESTIONS FOR FURTHER RESEARCH

The results of this investigation and some post-hoc analyses have led these investigators to suggest the following areas for further research:

1. The refinement and enlargement of the E^2Q instrument and a larger sample of both high school and college populations involved in the testing program.
2. The inclusion of a mini-course on Energy Use and the Environmental Impact be included in the high school science curriculum.
3. The inclusion of an interdisciplinary course involving Energy and the Environment and including the many factors suggested by G. T. Miller. These topics should be required for all college students both science majors and non-science majors.

APPENDIX A

Energy-Environment Quotient (E^2Q)

1. How much of the energy used in the gas stoves supplies the pilot lights?
(A) 10% (B) 25% (C) 50% (D) 65%

2. An incandescent lamp having the same light output: Which uses energy more efficiently? (A) fluorescent (B) incandescent
(C) both of these same efficiency (D) not a known fact

3. How many soft drink cans can be manufactured from recycled aluminum with the energy needed to make a single can from aluminum ore?
(A) three (B) five (C) twenty (D) forty

4. How long would a 100-watt light bulb burn on the energy needed to manufacture one throw-away soft-drink can or bottle?
(A) 10 minutes (B) 5 hours (C) 20 hours (D) 30 hours

5. How much of the energy stored in crude petroleum is lost between the oil well and a moving car? (A) 10% (B) 20% (C) 60% (D) 90%

6. The heat energy of a gallon of gasoline is equivalent to
(A) 5 man-days of labor (B) 15 man-days (C) 25 man-days of labor
(D) 50 man-days of labor

7. How much faster than their rate of production are we consuming our fossil fuels? (A) 10 times (B) 1,000 times (C) 100,000 times
(D) 1 million times

8. What fraction of the world's energy consumption occurs in the United States?
(A) about 6% (B) over 10% (C) over 20% (D) over 30%

9. Which of the following fuel resources is in greatest danger of exhaustion?
(A) coal (B) petroleum (C) natural gas (D) uranium

10. In the year 2000, American total energy demand will be
(A) the same as today (B) twice as much as today (C) three times as much as today (D) ten times as much as today

11. The overall gas mileage of the average American car is
(A) 8 (B) 12 (C) 15 (D) 17

12. Hydroelectric power supplies what portion of our electricity?
(A) 4% (B) 10% (C) 12% (D) 25%

13. In 1976 we imported what percent of our petroleum?
(A) 10% (B) 30% (C) 50% (D) 70%

14. The most serious air pollutant from coal-fired power plants is
(A) carbon monoxide (B) carbon dioxide (C) sulfur dioxide
(D) water vapor

15. The overall efficiency of a coal-fired power plant is about:
(A) 32% (B) 45% (C) 50% (D) 60%

APPENDIX A (continued)

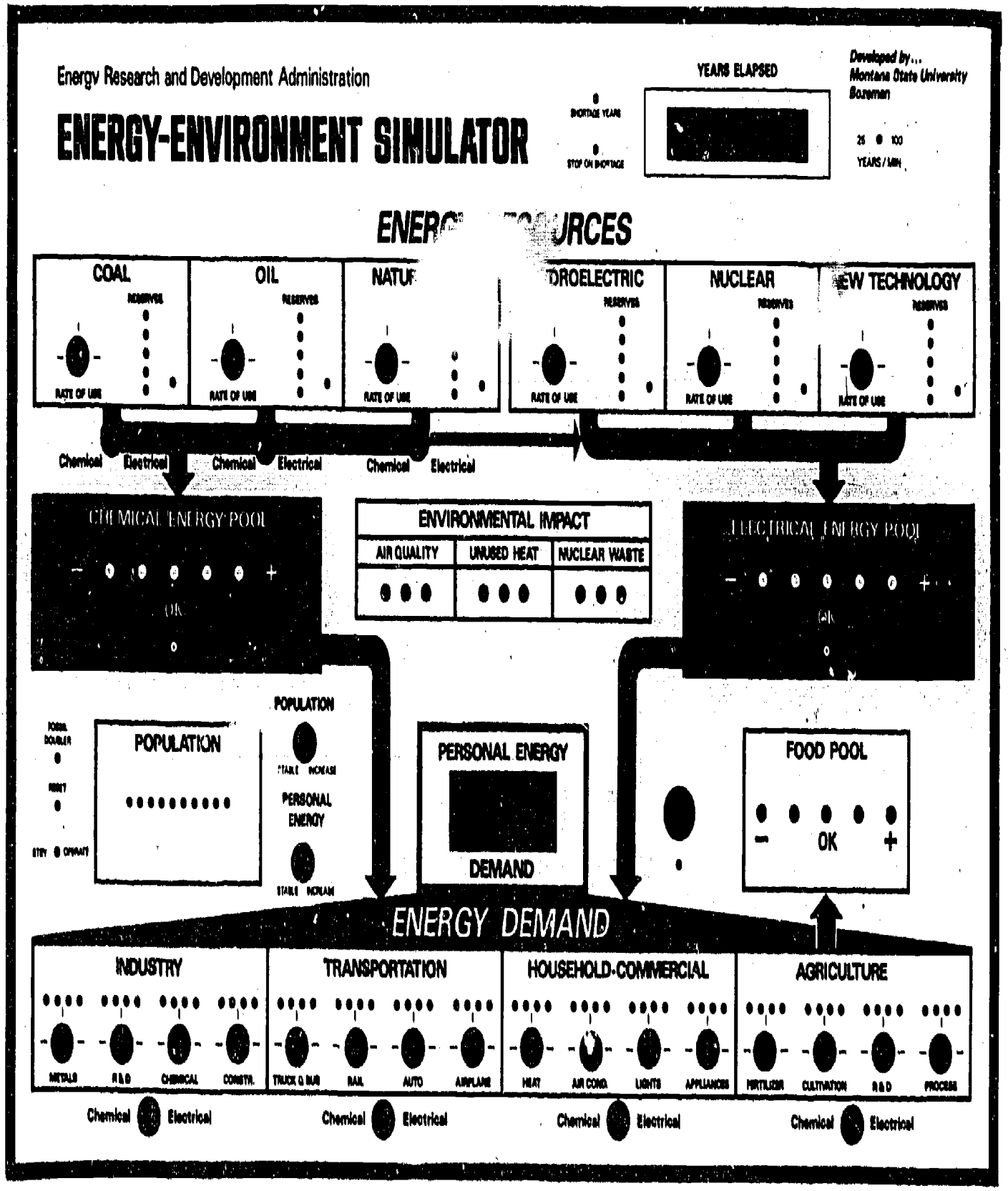
16. Nuclear power plants now supply about how much of our current electrical energy needs? (A) 5% (B) 10% (C) 15% (D) 25%

17. The two overall most serious components of air pollution harmful to humans are:
(A) carbon monoxide and carbon dioxide
(B) particulates and sulfur dioxide
(C) particulates and carbon monoxide
(D) lead and mercury

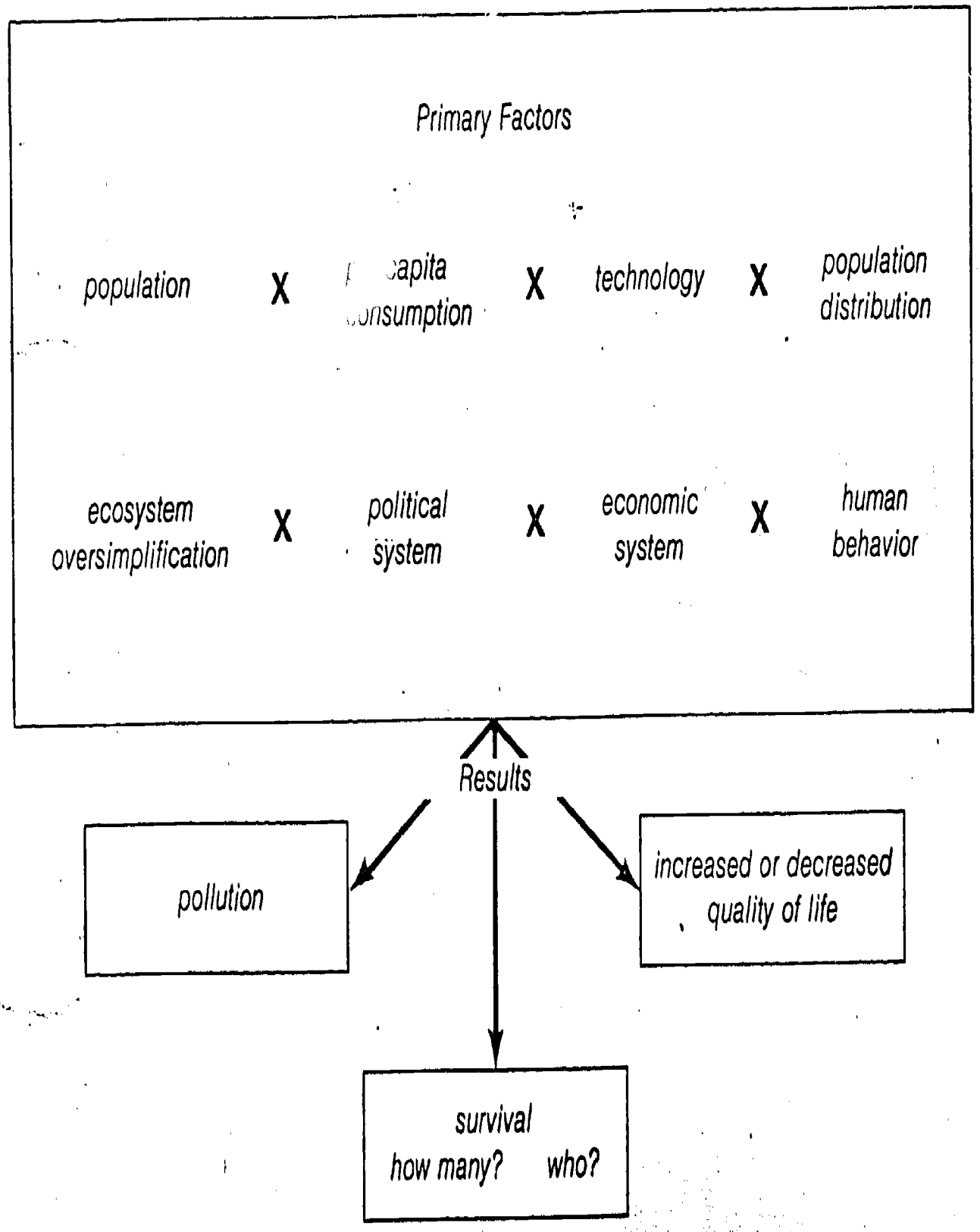
18. The energy source for the future which is still awaiting a major technological breakthrough for harnessing its energy is:
(A) nuclear fission (B) solar (C) geothermal (D) nuclear fusion

19. The Breeder Reactor is:
(A) a highly efficient solar cell
(B) a means of converting ordinary uranium into a useable reactor fuel
(C) a system for using geothermal energy
(D) only a theoretical future energy source

20. In the US today, there are about how many licensed nuclear power plants?
(A) 30 (B) 60 (C) 85 (D) 100


Energy Research and Development Administration
ENERGY-ENVIRONMENT SIMULATOR
YEARS ELAPSED
Developed by...
Montana State University
Bozeman
SHORTAGE YEARS
STOP ON SHORTAGE
25 100
YEARS / MIN
ENERGY RESOURCES
COAL
OIL
NATURAL GAS
HYDROELECTRIC
NUCLEAR
NEW TECHNOLOGY
RESERVES
RATE OF USE
Chemical
Electrical
CHEMICAL ENERGY POOL
ELECTRICAL ENERGY POOL
OK
ENVIRONMENTAL IMPACT
AIR QUALITY
UNUSED HEAT
NUCLEAR WASTE
POPULATION
POPULATION DOUBLER
PERSONAL ENERGY
PERSONAL ENERGY DEMAND
FOOD POOL
ENERGY DEMAND
INDUSTRY
METALS
R & D
CHEMICAL
CONSTR.
TRANSPORTATION
TRUCK & BUS
RAIL
AUTO
AIRPLANE
HOUSEHOLD-COMMERCIAL
HEAT
AIR COND.
LIGHTS
APPLIANCES
AGRICULTURE
FERTILIZER
CULTIVATION
R & D
PROCESS

Crude Model of the Primary Factors in the Environmental Crisis



APPENDIX C

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